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FIELD BALANCING IN THE REAL WORLD

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BY
BOB BRACHER

Abstract: Field Balancing in the Real World

Field balancing can achieve significant results when other problems are present in the frequency spectrum and multiple vibrations are evident in the waveform.

Many references suggest eliminating other problems before attempting to balance. That's great—if you can do it. There are valid reasons for this approach, and it would be much easier to balance machinery when other problems have been corrected. It is the theoretical ideal in field balancing. However, in the real world of machinery maintained for years by reacting to immediate problems, the classic vibration signature for unbalance is rarely seen.

We make most of our decisions with limited information. The decision to balance or not to balance is usually made the same way. This paper will demonstrate significant results of field balancing in the presence of multiple problems. By examining the data available and analyzing the probabilities, a reasonable chance for success can be assured.

Bob Bracher, Vibration and Training Specialist
Oak Ridge National Laboratory
managed by
Lockheed Martin Energy Research Corporation
Post Office Box 2008
Oak Ridge, Tennessee 37831-6411

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Acknowledgements

In a large, multifunctional company such as ORNL, it takes the efforts and contributions of several groups and individuals to bring about the change necessary to implement new techniques and ideas. Field balancing is not new. The idea of doing it on our own is new. Without the efforts of **Eddie Baird, Wayne Castleberry, Doug Edwards**, **Bob Hileman, Blake Van Hoy,** and **J. J. Vivyan** we would not have been able to perform the jobs mentioned in the case histories. Their efforts were made possible by the cooperation and support of managers, administrators, field maintenance and operations staff, and consultants of ORNL Plant & Equipment Division, ORNL Waste Management Remedial Action Division, and ORNL Environmental Restoration Division. Their continued efforts and support is appreciated.

CSI deserves some credit, too, for the many times they helped me resolve problems by telephone, in class, or in person. I particularly want to express my appreciation to the training, information desk, sales, software, hardware, and technical support groups, and specially to **Darla Adcock.**

Introduction

This paper will discuss case histories of field balancing jobs successfully accomplished at Oak Ridge National Laboratory (ORNL) in the presence of other vibration problems. A demonstration will explain by example the cases presented here. ORNL Journeyman Millwright **Doug Edwards** has agreed to assist me with this demonstration. I am grateful to him for his enthusiasm, skill, and dedication to predictive and proactive maintenance technologies. I enjoy working with him and I think you will too.

Overview

- List of CSI Equipment Used
- Field Balancing Basics: Decision to Field Balance
- Field Balancing Guidelines
- Case History One: The Underbalanced Overfire Blower
- Case History Two: The Confident Consultant
- Case History Three: The Doubtful Backup
- Demonstration of Multiple Problems
- Summary
- Recommendations
- References
- Appendices A & B

List of CSI® Equipment Used

- CSI 2115 Machinery Analyzer (a single-channel analyzer)
- CSI 404 Infrared Phototach
- CSI 440 Strobe Package
- CSI FAST Bal II Downloadable Program
- CSI Cascade Downloadable Program

Field Balancing Basics: Decision to Field Balance

Appearance of Unbalance Signature

The 1x magnitude is always increased with an unbalanced condition in rotating machinery, and it is usually highest in the radial direction. A single peak of excessive vibration at 1x running speed (or 1 order) is the classic unbalance signature. An accompanying waveform with a nearly perfect sine wave all but confirms it, right? If all of these things are true, the decision to field balance ought to be fairly easy to make from one set of data.

Other Factors

The problem arises when the forcing functions causing excessive 1x peaks are examined. Some, such as (1) bent shaft, (2) eccentricity, and (3) unbalance (center of gravity and center of rotation do not coincide), will respond to field balancing. Others, such as (4) severe looseness, (5) resonance near running speed, and (6) cracked shaft, will not respond successfully to field balancing. To complicate matters, *misalignment* can be mistaken for *unbalance*, and *unbalance* can be mistaken for *misalignment*. Misalignment can exhibit a 1x peak only. An overhung rotor can exhibit a high 1x in the axial direction or the radial direction, as well as a high 2x running speed peak.

Additional Tests to Confirm Unbalance

There are several ways to confirm that a field balance correction would decrease the vibration in rotating machinery: (1) On a single-plane rotor, phase data between the two bearings can help to confirm an unbalance condition. If the vibration of the two bearings is in phase, it is likely unbalance rather than misalignment. If the vibration is 180 degrees out of phase, the problem is likely misalignment. (2) Bump tests can rule out resonance within 10-20% of running speed (difficult or impossible to balance successfully). (3) Waterfall or cascade plots of coastdown and runup data can also help. All of the tests mentioned can be performed with a single channel analyzer, such as CSI's 2115, and a tach trigger.

A Note on the CSI Cascade Downloadable Program

When properly set up and operated, this program and the cascade plots produced can provide a wealth of reliable information quickly. CSI's Cascade Downloadable Program can reveal a resonant frequency too close to running speed, some transient events, and magnitude in relation to varying running speeds.

Balancing Standards

The decision to balance must take into consideration some standard that can be met. Currently, the primary standard used on commercial fans and pumps at ORNL is *customer satisfaction.* Objective standards for assessing field balancing results can be stated in maximum ounce or pound inches of residual unbalance remaining, or they can be stated in terms of a vibration magnitude limit at a certain location at 1x turning speed. Balancing standards will vary greatly with application, consequences of a machine failure, and customer requirements. The balancing of rigid rotors is covered in ANSI Standard S2.19-1989.

Field Balancing Guidelines

I. Preliminary Checks:

1. ☐ Complete Safety Work Permit according to YOUR COMPANY'S procedure.
2. ☐ Lockout/tagout equipment according to YOUR COMPANY'S procedure.
3. ☐ Inspect machine to be balanced *even if it has already been inspected* for any of the following problems that could preclude a satisfactory balance of the machine:
   - A. ☐ Cracks in foundation, grouting, welds, mounting hardware, rotor, etc.
   - B. ☐ Loose mounting bolts, debris, hardware, bearings, or couplings.
   - C. ☐ Missing parts: keys, set screws, balance weights, etc.
   - D. ☐ Damaged or broken parts: coupling, belts, bearings, etc.
   - E. ☐ Deformed parts: bent blade, misshapen belts, etc
   - F. ☐ Discoloration of moving parts
   - G. ☐ Excessive wear of visible moving parts.
   - H. ☐ Too much, too little, or burnt lubrication.
   - I. ☐ Dirt or debris on rotor
4. ☐ If any of the above items were checked and not corrected, report findings.
5. ☐ Clean the rotor of the machine to be balanced if it is dirty.

II. Typical Machinery Vibration Analyzer Equipment Setup:

1. ☐ Mount two vibration transducers radially at each bearing.
2. ☐ Install reflector tape for PhotoTach reference on shaft connected to rotor.
3. ☐ Mount PhotoTach to read reflector tape on center and perpendicular to rotor shaft axis.
4. ☐ Connect Phototach, multiplexer, and cabling to machinery analyzer and accelerometers.
5. ☐ Set up the job in the machinery analyzer.
6. ☐ Ensure that cords, accelerometers, and equipment will not interfere with shaft rotation.

CAUTION: From this point on, permits and lockout/tagouts may need to be suspended temporarily and then reinstated until the field balancing job is complete. Follow YOUR COMPANY'S procedures applicable to this job. Actual step-by-step of balance job will vary.

III. Typical Steps for Single-Plane Balancing

1. Acquire reference data.
2. Add one or more trial weights.
3. Acquire trial run data with trial weights in place.
4. Remove trial weights.
5. Determine whether to add or remove weight to balance.
   - A. Calculate correction weight and location required to balance machine (add or remove).
   - B. If adding weight, permanently affix correction weight; if removing, calculate area needed for removal and remove weight.
6. Check results and trim balance as necessary.
7. Repeat trim runs as necessary until within tolerance or acceptable to customer.
8. If trim balance calls for too much weight (>50% of correction), re-evaluate job.
9. Return machine to customer according to YOUR COMPANY'S procedure.

Case History One: The Underbalanced Overfire Blower

Nature of Involvement

No vibration readings had been taken on this fan before September 27, 1996. The resident millwright—Eddie Baird—had known of our program and some of our equipment, and he recommended our services to the relief supervisor.

Known Facts

New bearings had been installed in the motor, and the fan rotor was cleaned. The fan shook the entire second floor of the steam plant when the operators tried to run it. This fan had motor bearings only.

A set of vibration data was taken to verify that the fan was out of balance. The vibration was directional to some extent, with the horizontal reading >4x the vertical reading.

Relevant Spectrum

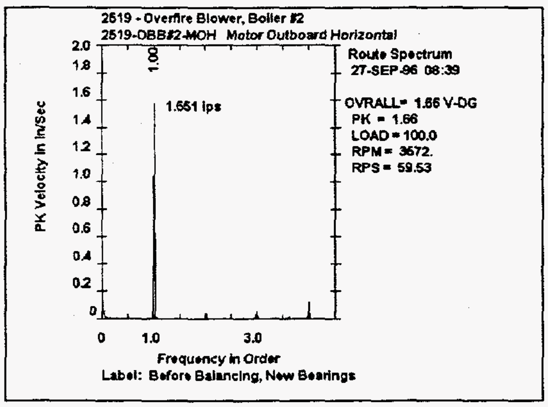

Fig. 1. Initial spectrum.

Spectrum After Balance

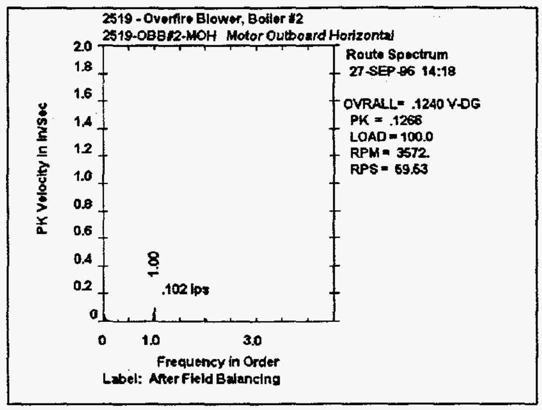

Fig. 2. Final spectrum.

Decision to Balance

The decision to balance was made on the basis of work already performed, major 1x vibration, and the comparatively low magnitude of the 2x-4x harmonics. During the balance job, the software help message (CSI FAST Bal II™) advised that the vibration was directional at one measurement location out of four. We continued to balance, and the spectrum above shows the pleasing result. Incidentally, the weight had to be placed at the same phase location as the original weight, hence the name for this case history.

Other Fan Problems

After field balancing, the 2x-4x fan harmonics are now ~20% of overall vibration. Additional data reveal that the vibration magnitudes are no longer directional. This suggests excitation vibration due to original high magnitude. Tracking and trending is the order of the day for this machine.

Case History Two: The Confident Consultant

Nature of Involvement

An outside consultant was hired by the ORNL Environmental Restoration Division to determine the "upgradeability" of two exhaust fans for one of our old reactor facilities, the Molten Salt Reactor Experiment (MSRE), nicknamed "ole salty". Our resident millwright—Bob Hileman—for that area advised his supervisor and the consultant of our services. We had already recommended a data collection route be started there.

Known Facts

Previous readings had been taken on this belt-driven, centrifugal fan, and the sheaves were realigned with a matched set of belts installed. New bearings were installed previously. The vibration readings were still too high. The data did not show a clearly unbalanced condition. However, in the face of increased speed, we recommended a coastdown test to determine the need to balance in order to reduce the vibration.

Relevant Spectrum

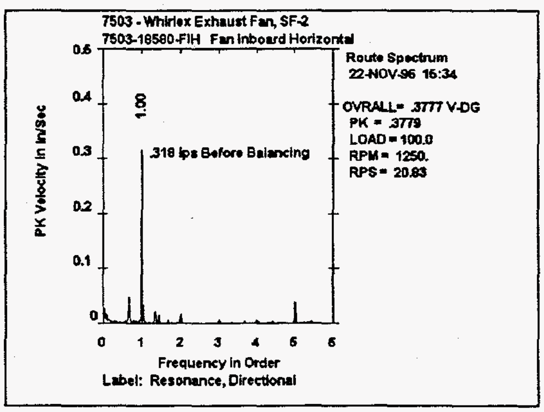

Fig. 3. Initial spectrum.

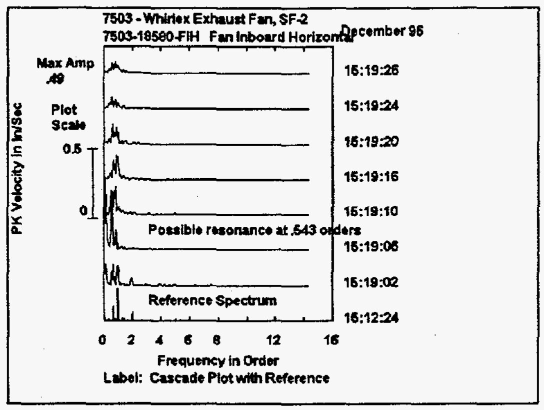

Fig. 4. Selected cascade spectra.

Decision to Balance

The highest magnitude of our data set was the 1x in Fig. 3. at .318 ips peak velocity. This represented about 80% of the total, with some subsynchronous energy (<1x frequencies) and the remainder mostly synchronous energy (whole number multiples of 1x running speed frequencies). The cascade spectra from the coastdown (Fig. 4.) provided further assurance we could significantly decrease the vibration by balancing. The only possible resonance was at .543x running speed, or slightly greater than 675 rpm, so it would have no adverse effects on our balancing. Also, although difficult to see, the 1x peak continues to decrease in magnitude as the fan slows down. This is a sure sign that field balancing can reduce vibration magnitude.

Sounds good, huh? Well, the problem was that this fan did *NOT* have an access to the fan rotor (or fan wheel, if you prefer). The consultant was confident that our diagnosis was correct and that we could reduce the vibration. A cover was made, a hole was cut in the fan housing, and field balancing was the next step. We had help from our Central Engineer—Blake Van Hoy—by telephone, but *I was sweating this one out!*

Spectrum After Balance

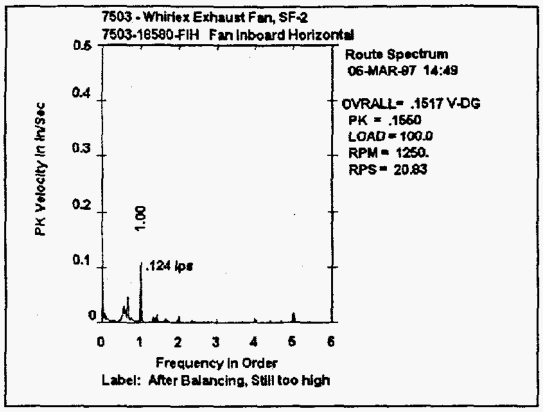

Fig. 5. Second spectrum.

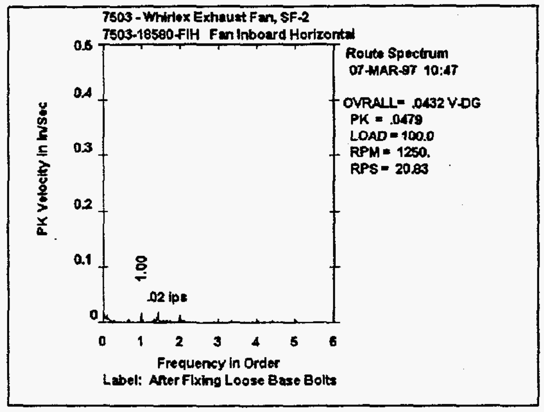

Fig. 6. Final spectrum.

The vibration for this fan was significantly reduced, but to my way of thinking, it was still too high (see Fig. 5.). It was running at only 1250 rpm, and it was headed for a speedup. We were fortunate to have two millwrights observing during this balance job. Good thing, too, because one of them—J. J. Vivyan—discovered the source of the remaining 1x vibration. During our trial weight run she noticed that a base bolt was loose. After all of the base bolts were tightened, the vibration was reduced even further, and this fan continues to operate smoothly. The happy customer, ORNL Environmental Restoration Division, placed this fan and its mate on periodic vibration data collection.

Other Fan Problems

There is some nonsynchronous energy (mixed-number multiples of running speed) present in the last spectrum, Fig. 6. Tracking and trending with realistic baselines, fault frequencies of bearings, belts, blade pass, and parameter banding will help us correct the problem at the customer's convenience before a breakdown.

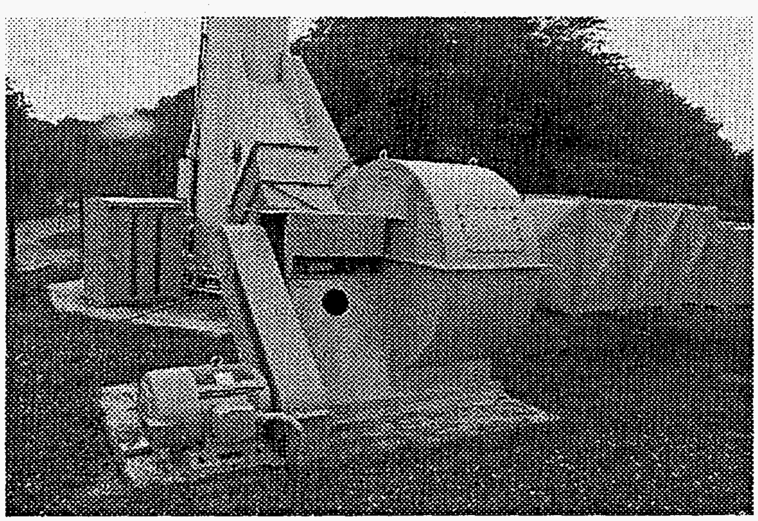

Fig. 7. Fan discussed in Case History Two.

Case History Three: The Doubtful Backup

Nature of Involvement

This particular fan was placed on routine periodic vibration monitoring along with several others, thanks in large part to our resident millwright in the area—Doug Edwards—who will assist me with the demonstration today. The first reading taken to establish baseline data showed serious problems.

Known Facts

The turbine-driven, direct-drive fan had recently been serviced. The turbine was rebuilt and it was aligned low to allow for thermal growth. No history was provided except the memory of the craft people working on this and similar jobs. This overhung fan served as a backup exhaust fan to an electric motor-driven primary, and it was operated once a week for about 30 minutes to verify that it was usable.

Relevant Spectrum

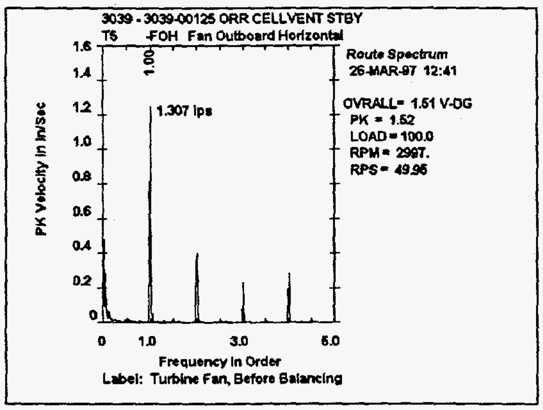

Fig. 8. Initial baselining the hard way.

Spectrum After Balance

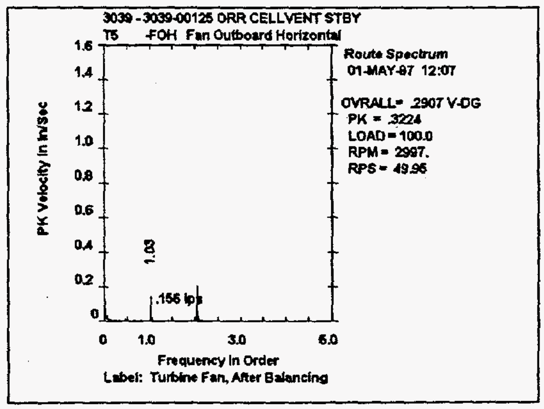

Fig. 9. Final spectrum.

Decision to Balance

The fan was exhibiting a 1x peak with a magnitude >85% of the overall vibration, and it was very high. Misalignment was not immediately suspected because the turbine was just rebuilt. Fan operation was improved but excessive vibration was noticeable.

Other Problems

This fan was difficult to balance because of the underlying misalignment, and we wound up with three weights in each plane. Using the "Add Weights" feature in the FAST Bal II software, we calculated a single correction weight for each of two weight planes, and the weights were welded in place. After balancing, the misalignment was evident (Fig. 9.). However, the customer was happy, the operators on the job said this fan had never run this smoothly, and the vibration was reduced by >5 times, a significant improvement. The machine awaits alignment when time permits. If pressed into service now, however, it would run much longer than before it was balanced.

Demonstration of Multiple Problems

The machine used for the demonstration is the *Baseline Trainer* available from CD International. For more information on this machine, contact Mr. Zane Dreja at CD International, Lewiston, New York (1-800-388-7972).

Summary

As demonstrated, field balancing can achieve significant results when other problems are present in the frequency spectrum and multiple vibrations are evident in the waveform (see Appendix A for waveform data.)

> **CAUTION:** *Always* correct other known problems if able to correct them before field balancing. *Never* attempt to field balance a machine if you are not *reasonably* certain it will significantly reduce the vibration.

Recommendations

- Adopt a troubleshooting strategy such as the one mentioned earlier ("...Decision to Field Balance"), or develop your own.
- Follow a checklist or guideline plan to avoid the frustration that comes from futile field balancing effort.
- Maintain records of balance jobs. If you have no record of where you have been no one will really know how far you have come except you.
- Use the reference materials listed to improve knowledge and skills.

References

The following publications are highly recommended for increasing your knowledge and skills in field balancing. Most also cover other vibration topics.

The Simplified Handbook of Vibration Analysis, Vols. 1 & 2, Crawford, CSI , 1992
Machinery Vibration Balancing, Wowk, McGraw-Hill, 1995
Shock and Vibration Handbook, Fourth Edition, Harris, Industrial Press, Inc.,1996
Reliability Magazine, Industrial Communications
P/PM Magazine, Second Childhood, Inc.
Vibrations, VI Press, Inc. (A Vibration Institute publication)

Appendix A

Spectra and Waveforms for All Case Histories; Bump Test Example

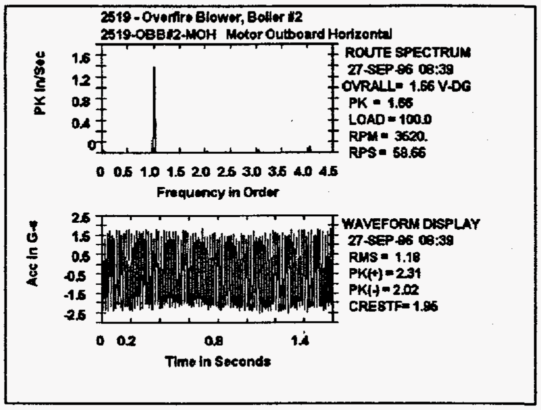

Fig. 10. Case History One.

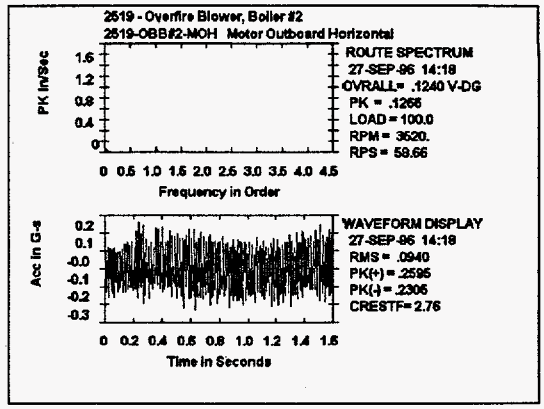

Fig. 11. Case History One final.

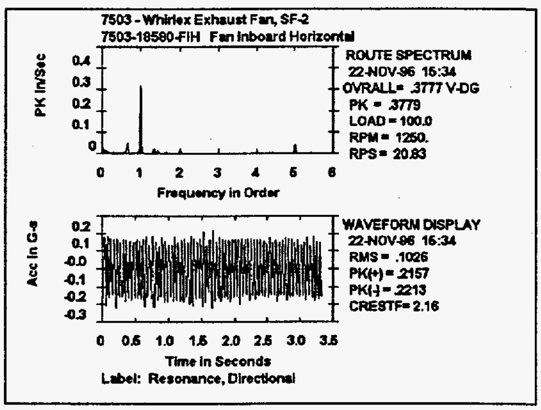

Fig. 12. Case History Two.

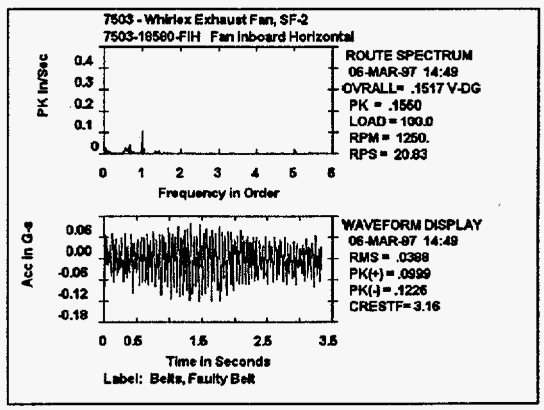

Fig. 13. Case History Two second.

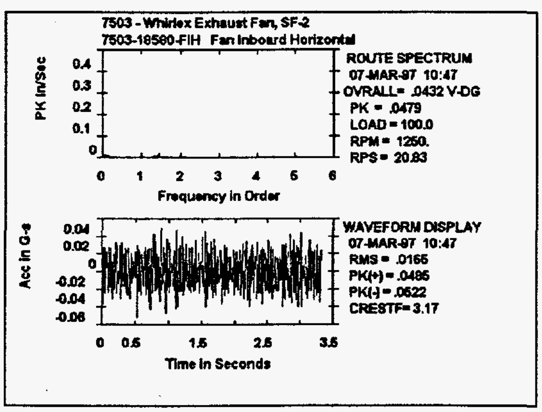

Fig. 14. Case History Two final.

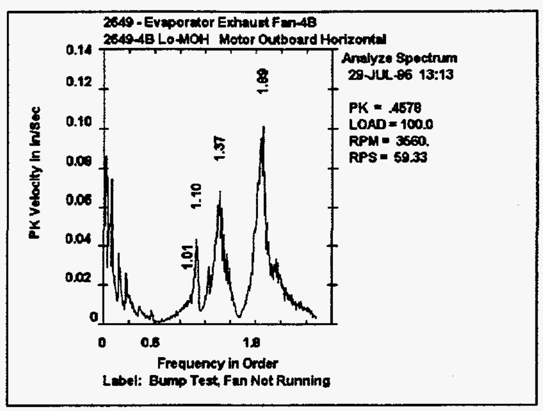

Fig. 15. Bump test resonance at 1.1x.

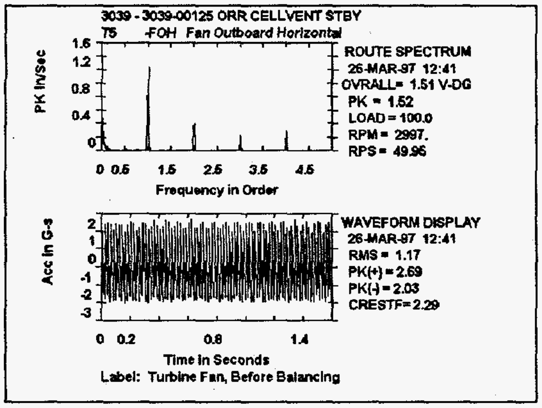

Fig. 16. Case History Three.

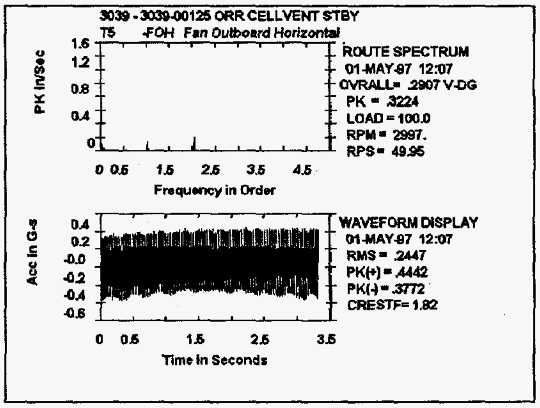

Fig. 17. Case History Three final.

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Appendix B

On the Job Assistance

The remaining pages contain copies of job aid cards for performing a single plane field balance using *CSI FAST Bal II.* They were developed and field tested by the ORNL Plant & Equipment Division Technical Training Department. ORNL is managed by Lockheed Martin Energy Research Corporation for the United States Department of Energy. The *CSI FAST Bal II User's Manual* and our *CSI 2115 Machinery Analyzer* were used to develop these. Accuracy of information contained cannot be guaranteed. CSI does not necessarily endorse the information, and CSI is not responsible for content.

2115 Analyzer, Card 7

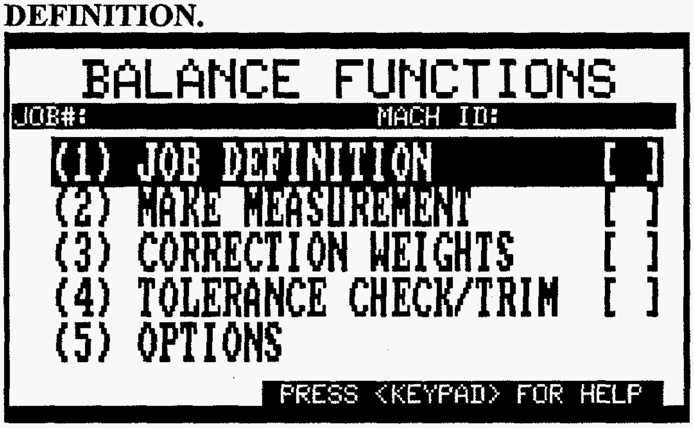
Field Balancing with FAST Bal II: JOB DEFINITION, Part 1

What to Do:	How to Do It
1. With **(1) JOB DEFINITION** highlighted, go to ***SCREEN R***.	Press **ENTER**
2. Fill in the job definition fields using PM numbers for **MACH ID.** Change the **SPEC:** field as needed; go to ***SCREEN S***.	Press ↑ or ↓ key; Fill in; Press **ENTER**
3. Complete ***SCREEN S*** according to the job**. NOTE: For a single plane balance, *SCREEN S* should look like the one below when you finish**.	Press ↑ or ↓ key; Fill in; Press **ENTER**
4. SCREEN T displays. Select the rotation of the machine from your preferred point of view; Set tach angle, RPM deviation (**DELTA**), and RPM1. **NOTE: in most cases, only 1 RPM is required**.	Press → or ←; Press ↑ or ↓ key; Fill in; Press **ENTER**

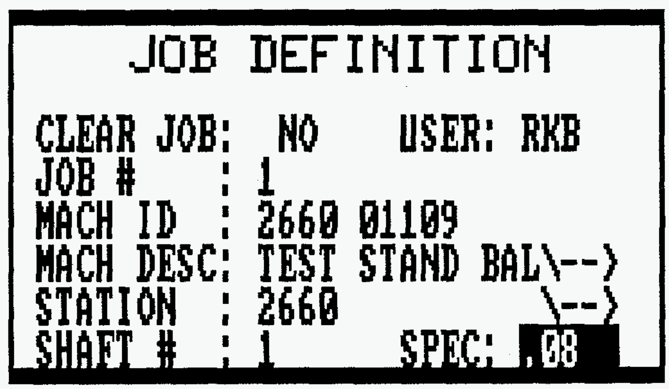
TIP: While in the FAST Bal II program, the RESET key will always return you to the BALANCE FUNCTIONS screen (*SCREEN Q.*) The routine routes are unavailable until you EXIT.

What to Do to EXIT FAST Bal II:	How to Do It
1. **Reminder: See CARD 6 for more information**. Go to UTILITY FUNCTION menu, ***SCREEN C,*** and select Item 6, SPECIAL FUNCTIONS. ***SCREEN O*** displays.	Press **UTILITY** key; Press ↑ or ↓ key; Press **ENTER**
2. Select Item 3, EXIT DWNLD PROG, and exit the program. The analyzer will return to a machine point on a route, if loaded.	Press ↑ or ↓ key; Press **ENTER**

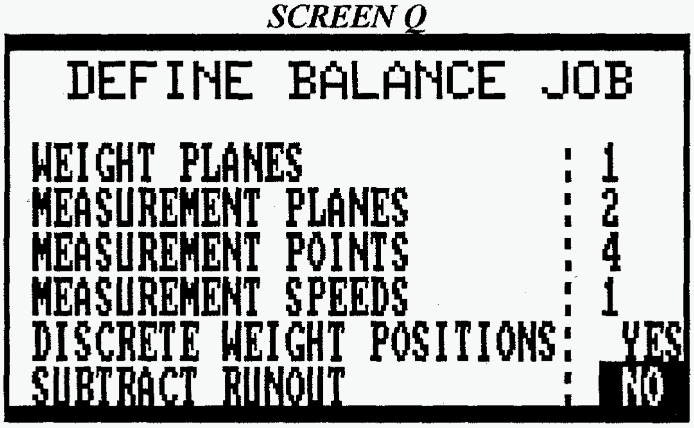
TIP: The DELE key will always take you to the previous screen while you are in JOB DEFINITION.



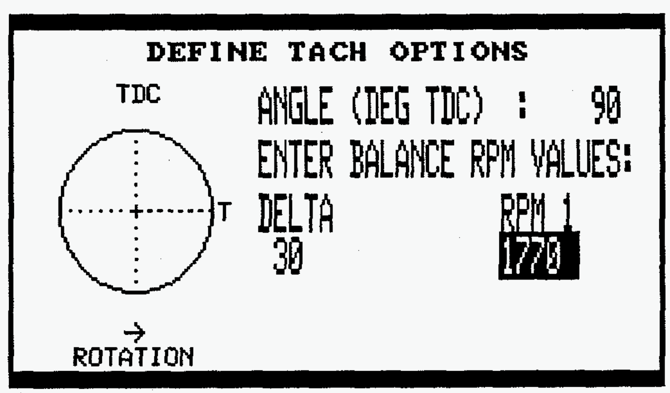
SCREEN Q



SCREEN R



SCREEN S



SCREEN T

SCREEN INFORMATION, Card 7

SCREEN Q, BALANCE FUNCTIONS (Default screen for FAST Bal II; [Main Menu])

1. JOB DEFINTION: Complete, specific details defining the balancing job are entered in the succeeding screens.
2. MAKE MEASUREMENT: Reference and trial runs can be setup and executed from succeeding screens.
3. CORRECTION WEIGHTS: Calculates correction weights and locations after reference and trial runs.
4. TOLERANCE CHECK/TRIM: Allows *actual* weight and location inputs, tolerance check, and trim weight calc.
5. OPTIONS: Not strictly a part of the program, the options listed allow data storage, recall, editing, review, loading, dumping, special data calculations, selection of balance mode, and default sensor setup. See CARD , OPTIONS, for more information.

SCREEN R, JOB DEFINITION

1. CLEAR JOB: Toggle to **YES** or **No** using any Alpha-Numeric key. **A YES selection allows you to clear the entire job or parts of it. If you want to save it, you must go to OPTIONS and STORE JOB before clearing it.**
2. USER: Insert 1-3 characters here to identify yourself as the user of the program..
3. JOB #: Identify job by number as desired. This number will be used to identify the job, and for storage and recall.
4. MACH ID: Please use the P&E Programmed Maintenance ID Number here if possible
5. STATION: Usually, the Building Number location of the equipment
6. SHAFT: The default is 1. If the machine has more than one shaft, enter the number of the shaft being balanced.
7. SPEC: Enter your balance specification for this job. The units will match your sensor "CONVERT TO" setup. For example, if you are converting to VELOCITY, this figure will be in inches per second (IPS.) If you are unsure of the balance specification, begin with .1ips.

SCREEN S, DEFINE BALANCE JOB

1. WEIGHT PLANES: Enter the number of weight planes to be balanced, 1-4.
2. MEAS PLANES: Up to 8 measurement planes may be input. Balancing may be with 2, but 4is recommended.
3. MEAS SPEEDS: Up to 6 speeds may be entered, however, "speeds x points" cannot exceed 24.
4. DISCRETE WEIGHT YES/NO: Use an ALPHANUMERIC key to toggle YES/NO. If any plane is restricted to a certain number of segments for adding or subtracting weight, toggle to YES. You can select CONTINUOUS for individual planes later.
5. SUBTRACT RUNOUT YES/NO: Use an ALPHANUMERIC key to toggle YES/NO. Toggling to YES allows runout data to be subtracted when using displacement probes. Normally, it is not used when using accelerometers.

SCREEN T, DEFINE TACH OPTIONS

1. ROTATION: Allows selection of Clockwise or Counterclockwise rotation according to user point of view.
2. ANGLE (DEG TDC): Allows selection of Tach pickup relative to the Top Dead Center (TDC) position.
3. DELTA: By inputting a number of 1-500, user specifies acceptable valid data limits above and below RPM.
4. RPM1, RPM2, *etc.*: 1-20,000 for each RPM may be input.

2115 Analyzer, Card 8

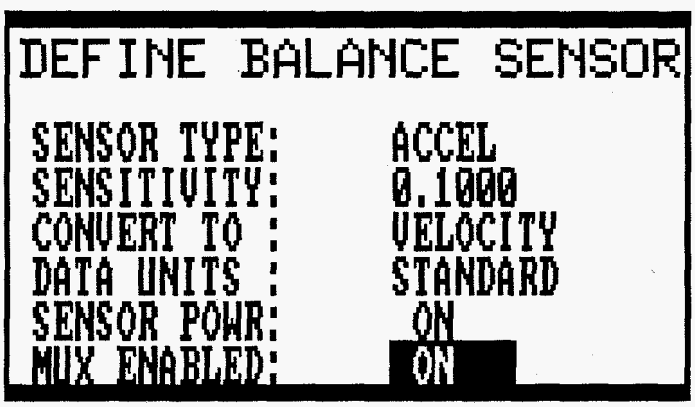
Field Balancing with FAST Bal II: JOB DEFINITION, Part 2

What to Do (continued from CARD 7)	How to Do It
1. Complete DEFINE BALANCE SENSOR screen *SCREEN U)* accurately. **NOTE: See *SCREEN U* below for usual setup.**	Press ↑ or ↓ key; Fill in; Press ENTER
2. *SCREEN V* displays; Define rotation, sensor point identification by channel, and sensor location from TDC for MEASUREMENT PLANE 1.	Press → or ← key; Press ↑ or ↓ key; Fill in; Press ENTER
3. *SCREEN W* displays; Define rotation, sensor point identification by channel, and sensor location from TDC for MEASUREMENT PLANE 2.	Press → or ← key; Press ↑ or ↓ key; Fill in; Press ENTER

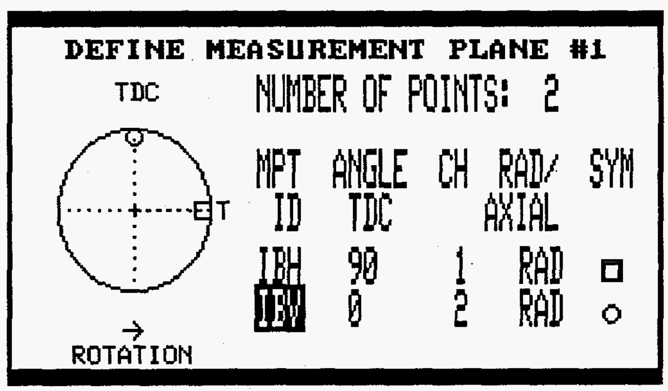
TIP: The displayed screen setups may be used as they are if appropriate, or you may reset according to your personal preference and point of view. Setup reference accuracy is a must!

4. *SCREEN X* displays; Confirm rotation and select number of weight positions, numbering with reference to rotation, and duplicate plane option. If option is **NO**, and >1 plane to define, go to **Item 11**, below.	Press → or ← key; Press ↑ or ↓ key; Fill in; Press ENTER
5. Complete the screen, DEFINE WEIGHT PLANE 2 (not shown.)	Repeat **Item 10**, above

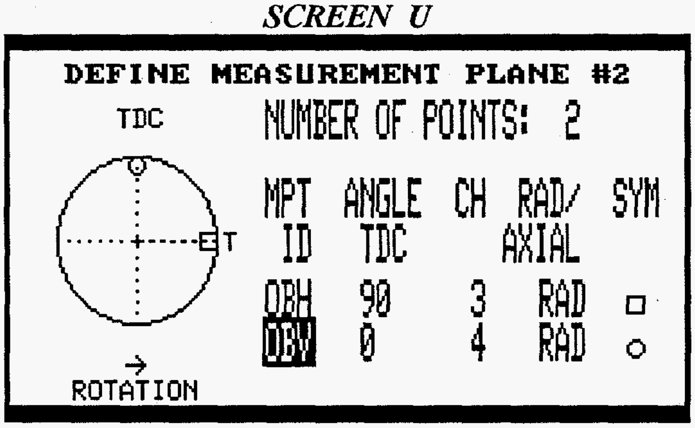
TIP: The DELE key will always take you to the previous screen while you are in JOB DEFINITION. The RESET key returns you to BALANCE FUNCTIONS.



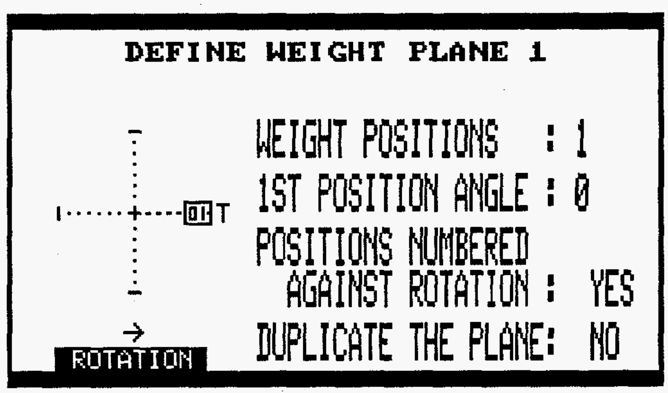
SCREEN U



SCREEN V



SCREEN W



SCREEN X

SCREEN INFORMATION, Card 8

SCREEN U, DEFINE BALANCE SENSOR

1) SENSOR TYPE: Toggle among accelerometer, displacement, velocity, and non-standard.
2) SENSITIVITY: Enter the sensitivity in volts per engineering unit. Check sensor or chart.
3) CONVERT TO: Toggle among choices to select sensor output. Normally, set to VELOCITY.
4) DATA UNITS: The default is STANDARD. Rarely will this require changing.
5) SENSOR POWER: Toggle between ON and OFF. Most of our sensors require this to be set to ON.
6) MUX ENABLED: Toggle among ON, OFF, and AUTO. If using the *CSI MODEL 642 Multiplexer*, this must be set to ON or AUTO. In AUTO, the analyzer will read all channels consecutively and accept data automatically. If you want data accepted in AUTO before the analyzer accepts it, you can force acceptance by pressing ENTER.

SCREEN V & SCREEN W, DEFINE MEASUREMENT PLANE 1, and ...PLANE 2:

NOTE: Each measurement plane can have up to 3 sensors defined with not more than one axial per plane. Accuracy with regard to TDC and TACH reference are necessary for correct calculations. Review the graphic screens after setup to ensure accuracy.

1) ROTATION: Toggle left and right arrows to clockwise or counterclockwise as appropriate.
2) NUMBER OF POINTS: Enter 1-3. Normally, there will be two measurement sensors per measurement plane.
3) MPT ID The default setup for 4 sensors is: IBH (Inboard Horizontal), Channel 1; IBV (Inboard Vertical), Channel 2 for MEASUREMENT PLANE 1; OBH (Outboard Horizontal), Channel 3; OBV (Outboard Vertical, Channel 4 for MEASUREMENT PLANE 2. You may change it as appropriate for your job and preference.
4) ANGLE TDC: Input (in degrees against rotation for default setup) sensor position relative to TDC.
5) CH: Enter a number 1-8 to reference the CHANNEL. This must be completed even if you are not using a mux so the identity of the sensor matches the channel every time a reading is taken.
6) RAD/AXIAL: Toggle between radial and axial depending on sensor orientation. Normally, all will be radial.
7) SYM: Shows the graphical symbol representing this sensor, and it cannot be changed. It is for reference only.

SCREEN X, DEFINE WEIGHT PLANE 1:

1) ROTATION: Confirm rotation for this display. Toggle with Left/right arrows.
2) WEIGHT POSITIONS: Input 1-100 for total number of available weight positions (equally spaced) for this weight plane.
3) 1ST POSITION ANGLE: Enter number (in degrees) from rotor reference of choice, tach position or TDC.
4) POSITIONS NUMBERED AGAINST ROTATION: Toggle YES/NO. The default is YES.
5) DUPLICATE THE PLANE: Toggle YES/NO. A YES will cause all other weight planes to be duplicates of PLANE 1.

SCREEN ? (not shown), DEFINE WEIGHT PLANE 2:

NOTE: It is possible to have two weight planes, one with discrete weight positions and one without, as in a fan rotor with a backing plate and blades attached to it (normally, a single-plane balance situation, but it could be two-plane balanced if necessary.) In cases such as this, define the additional planes as above.

2115 Analyzer, Card 9

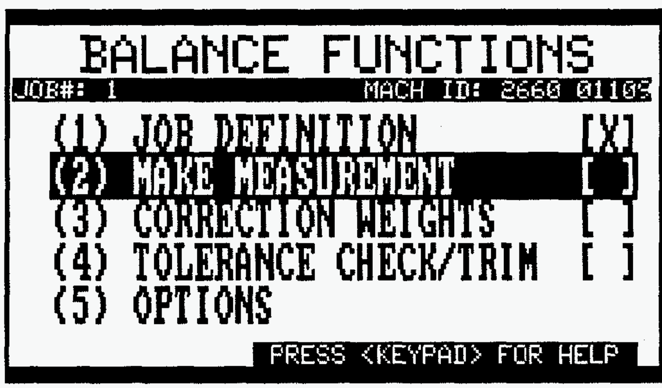
Field Balancing with FAST Bal II: MAKE MEASUREMENT, Part 1

What to Do (continued from CARD 8)	How to Do It
1. After defining the job, ***SCREEN Q*** displays. Go to MAKE MEASUREMENT.	Press ↑ or ↓ key; Press **ENTER**
2. ***SCREEN Y*** displays; select REFERENCE RUN.	Press **ENTER**
3. ***SCREEN Z*** displays; take measurements at the accelerometer points listed. In **AUTO** mode (see MUX, CARD 8,) the analyzer will take all the readings and accept them when Data Stability is in GOOD range.	Press **ENTER** Watch ***SCREEN A1***, below for data stability.

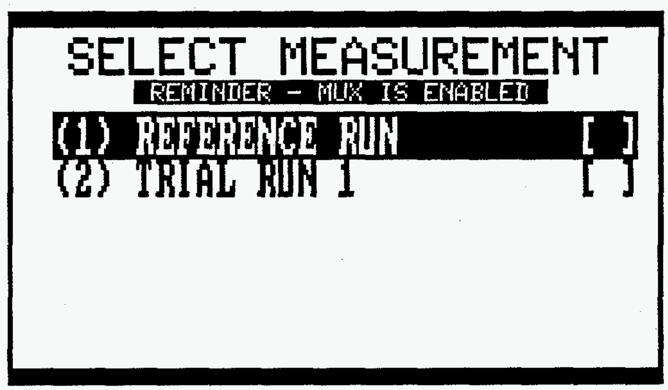
TIP: You can override analyzer by pressing the ENTER key during measurement to accept data.

What to Do if you must take a measurement again:	How to Do It
1. Go back to ***SCREEN Z***; highlight the identity of the measurement to be repeated; take the measurement again	Press **DELE**; Press ↑ or ↓ key; Press **ENTER**
2. ***SCREEN A1*** displays; wait until data for MAG (amplitude) and PHASE are stable, then ACCEPT the data.	Watch ***SCREEN A1***, below for data stability. Press **ENTER**

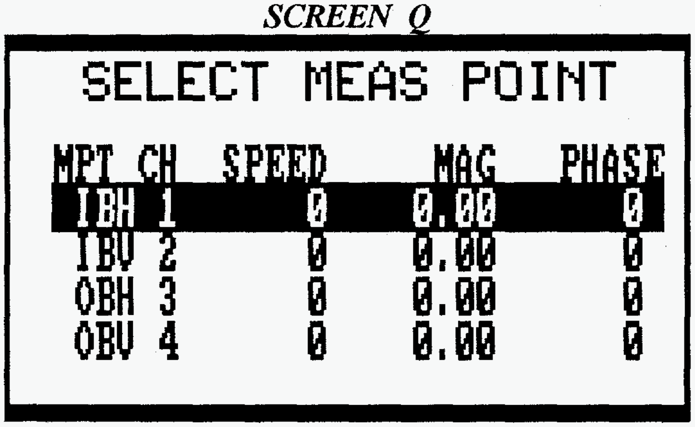
TIP: DELE key takes you back one screen; RESET returns you to BALANCE FUNCTIONS.



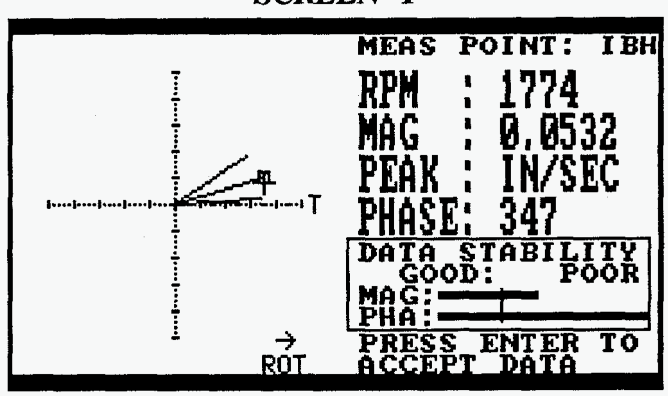
SCREEN Q



SCREEN Y



SCREEN Z



SCREEN A1

SCREEN INFORMATION, Card 9

SCREEN Q, See CARD 7

SCREEN Y, SELECT MEASUREMENT

NOTE: The display for SCREEN Y on the other side is for a single plane balance with no correction for runout. Normally, correction for runout is not necessary unless you are using a displacement probe.

1) REFERENCE RUN: Data is collected with no weights added.

2) TRIAL RUN 1: After collecting reference run data, a trial run is performed with weights added in the weight plane. If two-plane balancing is performed, a "TRIAL RUN 2" will display also. In that case, the second trial run will be made by adding weights to the second weight plane and removing (normally) the weights from weight plane 1.

SCREEN Z, SELECT MEAS POINT

CAUTION: Be sure to check that your measurement sensor location matches the description for the channel collecting data. Data will be invalid otherwise.

When ready to collect data and the channel one sensor is placed at the MPT listed (usually IBH, Inboard Horizontal), and data collection has begun, the A1 SCREEN displays (see below.)

SCREEN A1, (no title, shows graphic display in vectors

1) MEAS POINT: Displays the 3-digit identification of current sensor.

2) RPM: Displays the instantaneous rpm from phototach or other rpm sensing device.

3) MAG: Displays the *averaged* amplitude in units of output. Normally, it is inches per second (IPS) velocity.

4) RMS, PK, PK-PK: Displays unit of measurement according to set up. Normally, PK: IPS (for velocity)

5) PHASE: Displays the *averaged* phase of the high spot from the tach location, measured in degrees against rotation (normally, but may be reset by the user.)

6) DATA STABILITY: Live time display of phase and amplitude stability. The vertical bar separating the "GOOD" side from the "POOR" side marks where the average magnitude is varying + or - 5% and the average phase is varying + or - 2.5%.

7) Graphic Display:

- □ This box displays at the end of the instantaneous vector, showing the phase and relative amplitude.
- \+ This symbol indicates the average vector endpoint.
- T This displays position of the tach reference.
- ROT Shows current rotation direction selected.

NOTE: When the MUX ENABELED is set to AUTO(see CARD 8,) the analyzer will automatically enter data when it is in the GOOD stability range for both magnitude and phase. The user may override the analyzer AUTO mode by pressing the ENTER key to accept data.

2115 Analyzer, Card 10

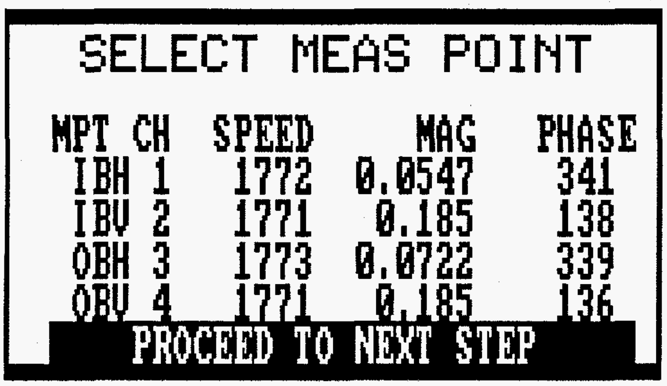
Field Balancing with FAST Bal II: MAKE MEASUREMENT, Part 2

What to Do (continued from CARD 9)	How to Do It
1. After completing measurements, ***SCREEN Z*** displays. PROCEED.	Press **ENTER**
2. If there were no potential problems, ***SCREEN Y*** displays. Go to TRIAL RUN (CARD 11.)	Press **ENTER** Press **ENTER**

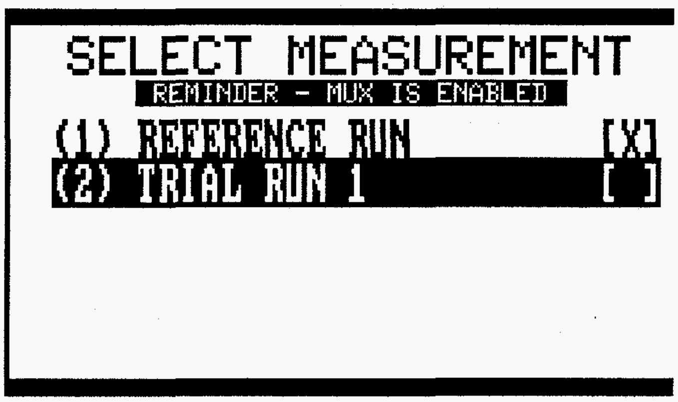
TIP: The Reference Run data is analyzed and you will be alerted to conditions posing potential problems. Read all the screens and make your best judgment whether or not to continue. If preliminary checklist was completed, balancing should proceed. SEE EXAMPLE BELOW

What to Do if you get a USER ALERT!!:	How to Do It
1. ***SCREEN A2*** is one of many screens that may display. Note the problem, and go to the HELP MESSAGE (***SCREEN A3***) for more information.	Press **KEYPAD;**
2. After assessing messages, Go to TRIAL RUN (CARD 11.)	Press **ENTER** twice

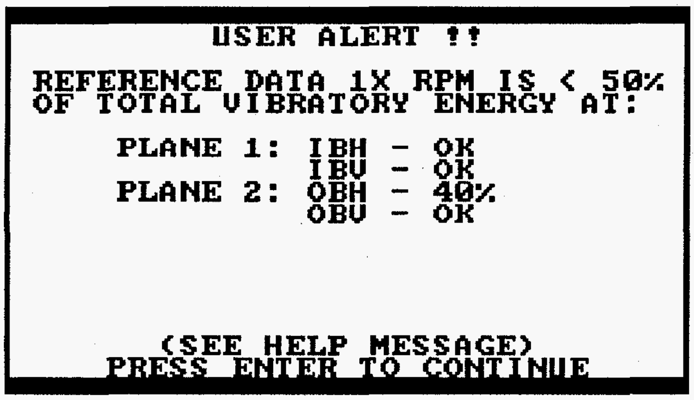
TIP: The DELE key will always take you to the previous screen while you are in JOB DEFINITION. The RESET key returns you to BALANCE FUNCTIONS.



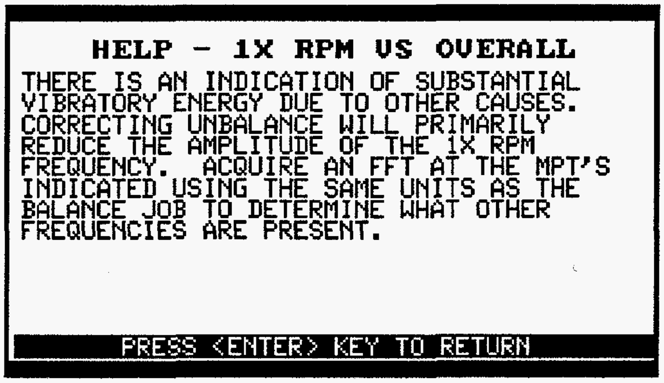
SCREEN Z



SCREEN Y



SCREEN A2



SCREEN A3

SCREEN INFORMATION, Card 10

SCREEN Y, SELECT MEASUREMENT

NOTE: The display for SCREEN Y on the other side is for a single plane balance with no correction for runout. Normally, correction for runout is not necessary unless you are using a displacement probe.

1) REFERENCE RUN: Data is collected with no weights added. When the reference run is complete, an "X" appears next to it on the screen. However, you may retake any data necessary

2) TRIAL RUN 1: After collecting reference run data, a trial run is performed with weights added in the weight plane. If two-plane balancing is performed, a "TRIAL RUN 2" will display also. In that case, the second trial run will be made by adding weights to the second weight plane and removing (normally) the weights from weight plane 1.

SCREEN Z, SELECT MEAS POINT

CAUTION: Be sure to check that your measurement sensor location matches the description for the channel collecting data. Data will be invalid otherwise.

SCREEN A2, USER ALERT!!

NOTE: This is just one of many USER ALERT screens which may display to help you determine whether or not balancing will correct the vibration problem. This particular screen is alerting to the fact that <50% of the total vibration energy is due to 1x rpm, but this exists only at one point, OBH in plane 2. Use this information along with the HELP screen information to determine whether or not to continue balancing. Normally, you would continue, especially if the balancing checklist was completed and unbalance was suspected.

SCREEN A3, HELP - 1X RPM VS OVERALL

The HELP screen, if available, is accessed by pressing the KEYPAD key on the analyzer. Read it completely to help you make a decision on what to do next. Most of the time, you would continue with the balancing job. If it does not reduce the vibration significantly, there are other problems causing the vibration.

2115 Analyzer, Card 11

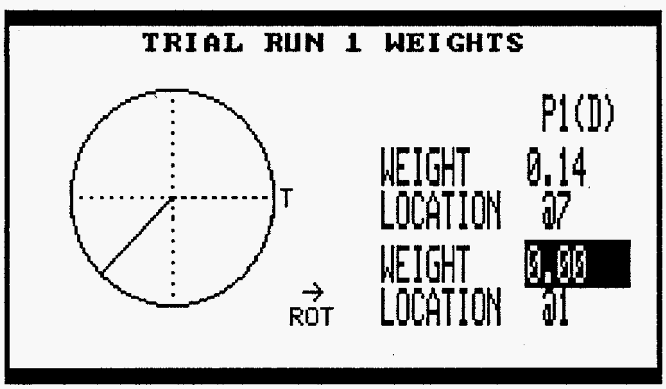
Field Balancing with FAST Bal II: <u>MAKE MEASUREMENT, Part 3</u>

What to Do to perform TRIAL RUN (continued from CARD 10)	How to Do It
1. *<u>SCREEN A4</u>* displays; Enter weights and location for the trial run (for discrete wt. planes, by position number; otherwise, degrees against rot.) A vector displays on graph showing position relative to tach position **T.**	Press ↑ or ↓ key; Fill in; Press **<u>ENTER</u>**
2. *<u>SCREEN Z</u>* displays; take measurements at the accelerometer points listed. In **AUTO** mode (see MUX, CARD 8,) the analyzer will take all the readings and accept them when Data Stability is in GOOD range.	Press **<u>ENTER</u>** 5 times In AUTO mode, Press **<u>ENTER</u>** 2 times
3. *<u>SCREEN Z</u>* displays again (as shown below.) Advance to *<u>SCREEN A5</u>*, with the REMINDER to remove trial weights or include them in the next trial definition.	Press **<u>ENTER</u>** one or two times.

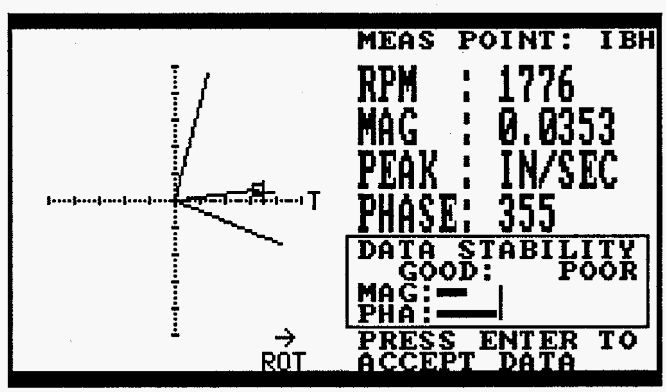
TIP: If using two weight planes, run one plane for Trial Run 1 and the other weight plane for Trial Run 2 (see below.) See other side for additional information.

What to Do to perform TRIAL RUN on WT. PLANE 2, if necessary:	How to Do It
4. *<u>SCREEN Y</u>* displays with TRIAL RUN 1 [X] , and TRIAL RUN 2 will be ready to run [ ]. To complete, follow the steps above *again*. **<u>NOTE:</u>** **<u>Screens will be slightly different. Observe carefully.</u>**	**<u>REPEAT Steps 1 thru 3, above.</u>**

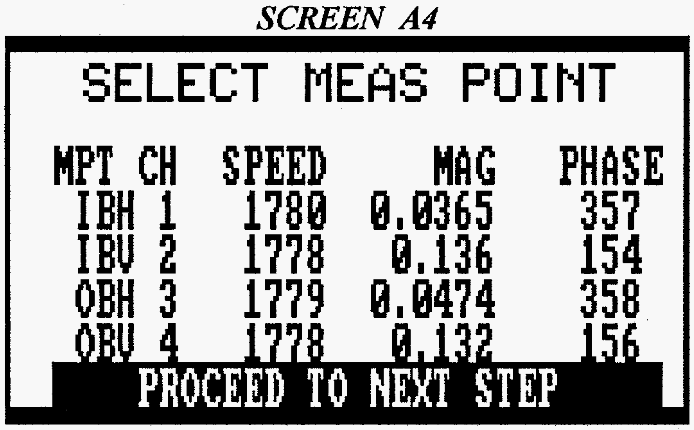
TIP: It is not possible to show all of the incident display screens for the various setups in FAST BAL II, so *READ EACH SCREEN CAREFULLY*, and complete information accurately.



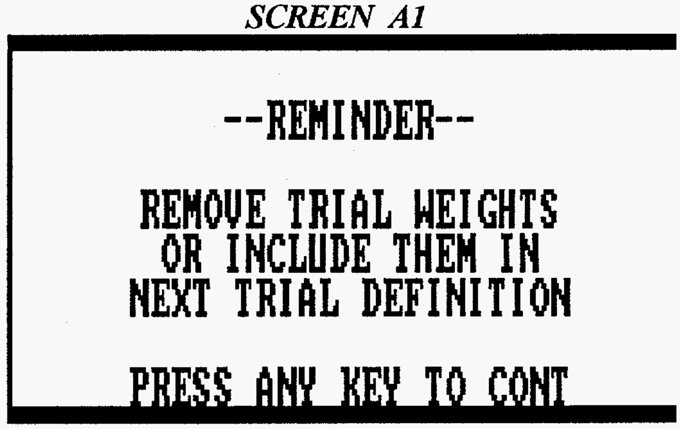
SCREEN A4



SCREEN A1



SCREEN Z



SCREEN A5

SCREEN INFORMATION, Card 11

SCREEN A4, TRIAL RUN 1 WEIGHTS

Vector(s) show the location relative to the tach position "T" of the trial weights for this weight plane.

P1 (D): Identifies PLANE 1 with Discrete Weight Positions selected in a previous setup screen.

P1 (C): (NOT SHOWN) Identifies PLANE 1 with Continuous Weight Positions selected

P2 (D), (P2 (C): (NOT SHOWN) Same as above, but for the second weight plane.

CAUTION: Perform trial runs by adding trial weights to only one weight plane at a time; you may remove the trial weights from the first run or leave them on, but be sure the program knows what you did.

WEIGHT 0.14: This tells the quantity of weight, whether ounces or grams, you are adding to the weight plane.

LOCATION: The "@" symbol always precedes the location number for discrete weight positions, and the numbering is against rotation from the 0 reference ***unless the default setup was changed.***

You may add up to two different weights at up to two different locations per weight plane. One is usually enough.

ROT: The → or ← above the abbreviation for rotation reveals the rotation direction selected.

SCREEN A1, SCREEN Z (see CARD 9)

SCREEN A5, REMINDER (self explanatory)

TRIAL RUN NOTES: Up to four weight planes may be ddefined, and multiple speeds may be defined. Generally, you would proceed as follows: 1: Add trial weight to WEIGHT PLANE 1; 2: Input weight and location; 3: Acquire data for all measurement points; 4: If multiple speeds, acquire data for each specified speed. 5: Repeat for each defined weight plane. If you need more information, see *CSI FAST Bal II User's Manual*, Chapter 4.

2115 Analyzer, Card 12

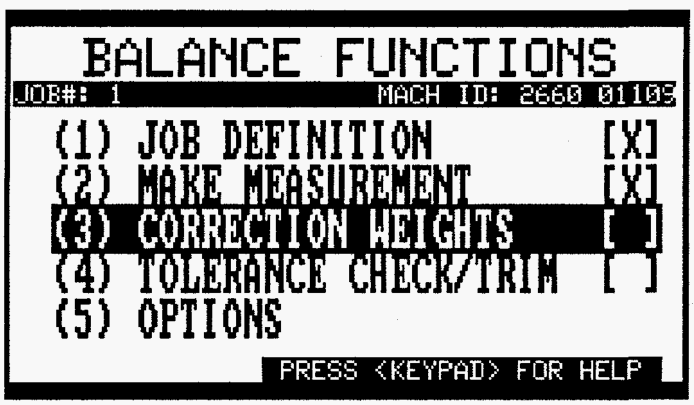
Field Balancing with FAST Bal II: <u>*CORRECTION WEIGHTS,*</u>

What to Do (continued from CARD 11)	How to Do It
1. After completing all trial runs, ***SCREEN Q*** displays. Go to ***SCREEN A6,*** CORRECTION WEIGHTS.	Press **ENTER**
2. ***SCREEN A6*** displays. To accept ***Add weight with trial weights left in place***, toggle TW Off/On	Press **ENTER** two times or **SEE BELOW**

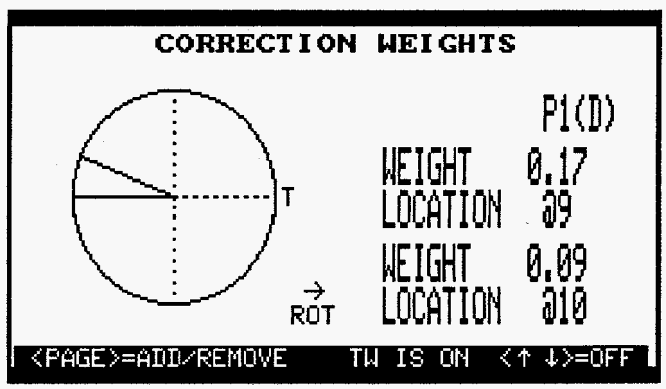
TIP: You do not have to add the exact weight required, but you will get better results if you do. CARD 13 describes how to record the *actual applied weight and location.*

What to Do to (alternatives to STEP 2, above):	How to Do It
2. After completing STEP 1, above, ***SCREEN A6*** displays. To: ***Add weight with trial weights removed.***	Press ↑ or ↓ key once; Press **ENTER**
2. After completing STEP 1, above, ***SCREEN A6*** displays. To: ***Remove weight with trial weights removed,*** <PAGE> ADD/REMOVE	Press **PAGE;** Press **ENTER**
2. After completing STEP 1, above, ***SCREEN A6*** displays. To: ***Remove weight with trial weights left on,*** <PAGE> *and* toggle	Press **PAGE;** Press ↑ or ↓ key once; Press **ENTER**

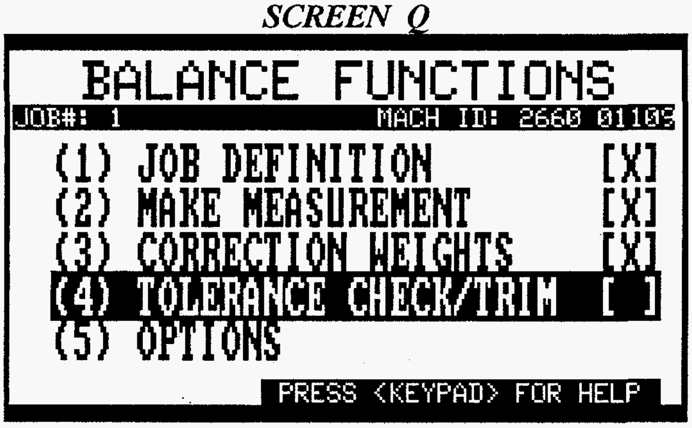
TIP: It is not possible to show all of the incident display screens for the various setups in FAST BAL II, so *READ EACH SCREEN CAREFULLY*, and complete information accurately.



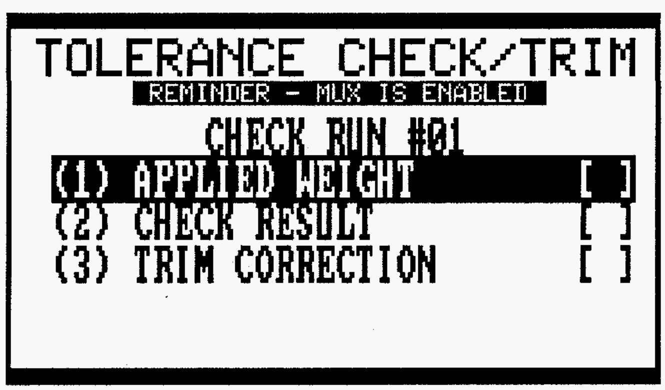
SCREEN Q



SCREEN A6



SCREEN Q



SCREEN A7

SCREEN INFORMATION, Card 12

SCREEN Q (see CARD 7)

SCREEN A6

Vector(s) show the location relative to the tach position **"T"** of the trial weights for this weight plane.

P1 (D): Identifies PLANE 1 with Discrete Weight Positions selected in a previous setup screen.

P1 (C): (NOT SHOWN) Identifies PLANE 1 with Continuous Weight Positions selected

P2 (D), (P2 (C): (NOT SHOWN) Same as above, but for the second weight plane.

DESCRIPTION OF CAPTION AND SCREEN APPEARANCE FOR THE FOUR ALTERNATIVE WEIGHT CORRECTIONS:

1. **<PAGE>=ADD/REMOVE TW is ON <↑ ↓>=OFF:** (Default with no minus sign before weight number)
   You are planning to ADD weight with the trial weights left in place.
2. **<PAGE>=ADD/REMOVE TW is OFF <↑ ↓>=ON**: (No minus sign before weight number)
   You are planning to ADD weight with the trial weights removed.
3. **<PAGE>=ADD/REMOVE TW is ON <↑ ↓>=OFF:** (A minus sign appears before weight number)
   You are planning to REMOVE weight with the trial weights left in place.
4. **<PAGE>=ADD/REMOVE TW is OFF <↑ ↓>=ON**: (A minus sign appears before weight number)
   You are planning to REMOVE weight with the trial weights removed.

SCREEN A7, TOLERANCE CHECK/TRIM

REMINDER: MUX IS ENABLED: This means you must be using the *CSI MODEL 642 Multiplexer* to collect your data.

CHECK RUN #1: This will tell you which correction run your are on. You should not need more than two correction runs.

1) APPLIED WEIGHT: When blank, it signifies you have not entered the actual weight you will be applying. When an **X** appears, the correction weight has been applied (added or removed, whichever is the case.)
2) CHECK RESULT: This lets you see a graphical representation of the correction results after your correction run. The correction run steps appear on the next card, CARD 13.
3) TRIM CORRECTION: After your correction run, you may want to trim machine in by leaving the correction weights on. This will let you do that.

2115 Analyzer, Card 13

Field Balancing with FAST Bal II: TOLERANCE/TRIM CHECK,

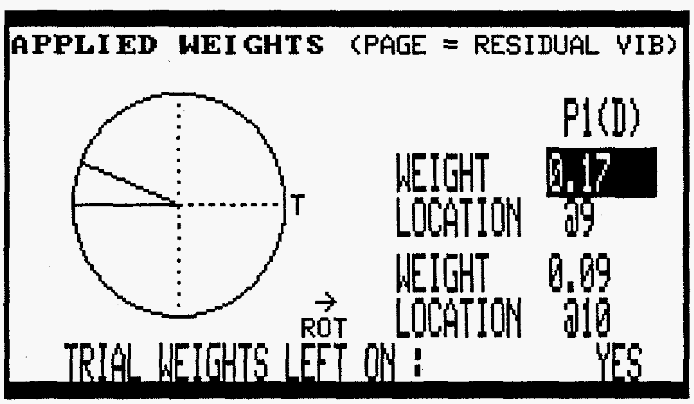
What to Do (continued from CARD 12)	How to Do It
1. After completing the correction weight setup, ***SCREEN A8*** displays. Enter the exact weight and location of the weight applied.	Press ↑ or ↓ key, Fill in; Press ENTER
2. ***SCREEN Z*** displays. The same sequence as for reference and trial runs ensues. ***SCREENS A1, Z and possibly A3*** display.	See CARDS 9 & 10 if necessary to collect data.
3. After the correction run, ***SCREEN A7*** displays. Check the result.	Press ENTER

TIP: Trim runs are OPTIONAL depending on your acquired results. If the phase vector fluctuates greatly (*SCREEN A1, CARD 9*, you will not improve the balance by continuing.

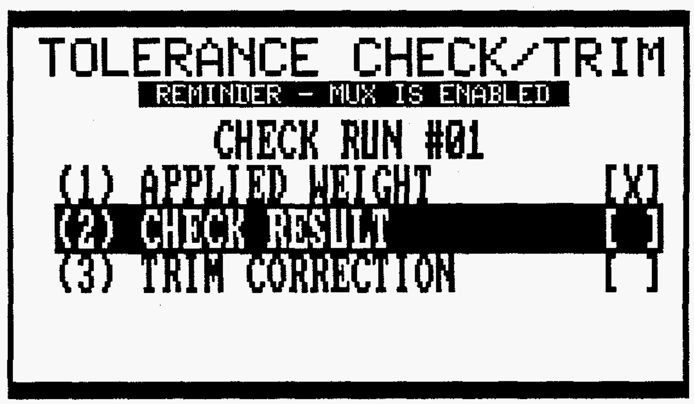
What to Do to get HELP	How to Do It
1. Go to the help screen it is available from many screens in the program.	Press KEYPAD; After, Press ENTER

TIP: IF all of the *SCREEN A9's* looks like the one below, the balance job is within the tolerance you set. IF there are some points outside the circle, the vibration magnitude is out of tolerance.

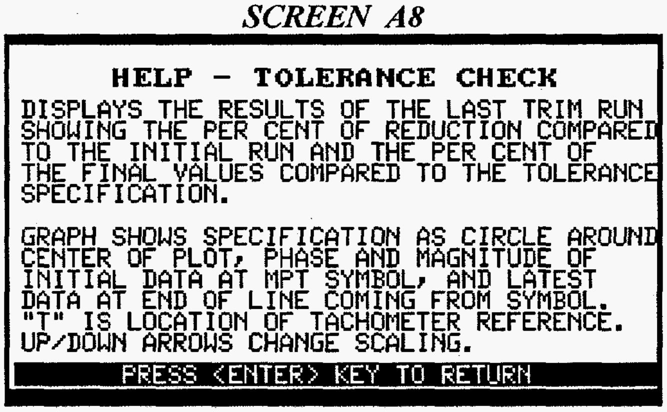
TIP: It is not possible to show all of the incident display screens for the various setups in FAST BAL II, so *READ EACH SCREEN CAREFULLY*, and complete information accurately.



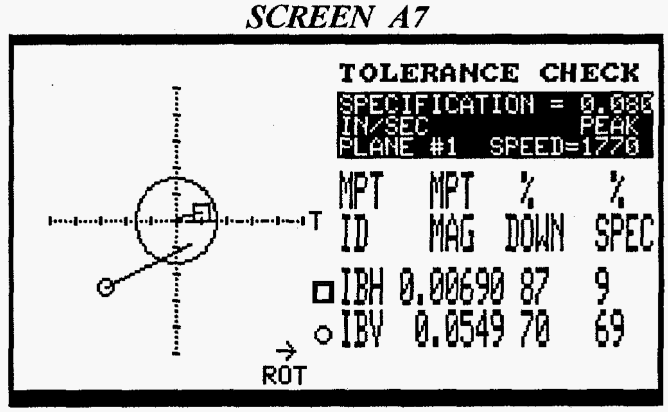
SCREEN A8



SCREEN A7



SCREEN A3



SCREEN A9

SCREEN INFORMATION, Card 13

SCREEN A8, APPLIED WEIGHTS

(PAGE=RESIDUAL VIBRATION): This is a reminder to let you know you may view a prediction of the residual vibration before actually performing the vibration check. This is especially useful if you applied weight differing from the correction weight recommendation.

Vector(s) show the location relative to the tach position "T" of the trial weights for this weight plane.

P1 (D): Identifies PLANE 1 with Discrete Weight Positions selected in a previous setup screen.

P1 (C): (NOT SHOWN) Identifies PLANE 1 with Continuous Weight Positions selected

P2 (D), (P2 (C): (NOT SHOWN) Same as above, but for the second weight plane.

WEIGHT: This tells the quantity of weight, whether ounces or grams, you are adding to the weight plane.

LOCATION: The "@" symbol always precedes the location number for discrete weight positions, and the numbering is against rotation from the 0 reference ***unless the default setup was changed.***

You may add up to two different weights at up to two different locations per weight plane. One is usually enough.

ROT: The → or ← above the abbreviation for rotation reveals the rotation direction selected.

TRIAL WEIGHTS LEFT ON: YES: This is a statement. If the trial weights need to be removed, you must back up in the program to do so.

SCREEN A7 (See CARD 12)

SCREEN A3, HELP (this particular help screen is for TOLERANCE CHECK)

SCREEN A9, TOLERANCE CHECK

SPECIFICATION=0.080: This is the tolerance you entered in setup. If your line from the points on the graph extend into the circle, your 1X vibration is within the tolerance you entered (see CARD 7.)

IN/SEC PEAK: This indicates you are reading out in velocity, inches per second, peak (averaged.)

PLANE #1 SPEED=1770: This identifies the weight plane of interest, and the speed of interest.

MPT ID: The symbols and letters directly below identify the measurement points of the measurement plane.

MPT MAG: The numbers below display the magnitude or amplitude of the last reading for the corresponding MPT

% DOWN: This is a comparison of the last reading to the first reading of this balance job. If it is a full balance job, the last reading will be compared to the REFERNCE RUN. If it is a Trim only balance job, it will be compared to the first reading of the Trim only.

% SPEC: This compares the last reading to the balance specification as defined for this job.